Exploring farmers' vulnerability and agrobiodiversity in perspective of adaptation in Southern Cameroon

Forbi Preasious Funwi[ab], Denis Jean Sonwa[c], William Armand Mala[b], Takanori Oishi[d],
Marlene Toukam Ngansop[ab], and Marie Mbolo[b]
[a] Millennium Ecologic Museum, Cameroon
[b] Department of Plant Biology, University of Yaounde I, Cameroon
[c] Center for International Forestry Research (CIFOR), Central African Regional Office, Cameroon
[d] African Studies Center – Tokyo University of Foreign Studies, Japan

Abstract

Climate change is a global phenomenon that indiscriminately affects all sectors of the economy and social life-support systems. New trends in climate change will leave high impacts on rural populations, whose livelihoods depend on agriculture and natural resources, leaving them increasingly vulnerable. Agrobiodiversity management is a promising method of facilitating adaptation to climatic changes. Hence, this study aimed to investigate the vulnerability of farmers and assess agrobiodiversity in Southern Cameroon in the context of adaptation. Focus groups and surveys were conducted in 31 villages in Ayos and Bokito in Southern Cameroon. The vulnerability index was computed for selected indicators of different components of vulnerability (exposure, sensitivity, and adaptive capacity). Data analysis revealed that in the two communities, the majority of villages were moderately vulnerable to climate change. However, Bokito community appeared to be more vulnerable than Ayos community. Farmers adopted several climate adaptation strategies such as crop replacement, replanting, planting of trees, cultivation of crops in swampy areas, and the expansion of cocoa cultivation in savannahs. Rich agrobiodiversity was identified in both sites; however, Ayos was richer than Bokito for wild plants, wildlife, and fisheries resources. The Bokito community also had a higher dependence on agriculture. Sustainably managing the rich agrobiodiversity of the landscape can provide a critical method to build the resilience of farmers.

Keywords: farmers, climate change, vulnerability, agrobiodiversity, adaptation

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1. Introduction

Climate change is a global phenomenon that indiscriminately affects all sectors of the economy and social groups (Dendir and Simane 2019). This change manifests itself through rising temperatures, changing rainfall patterns, and frequent and severe weather events, which increasingly affect societies and ecosystems globally and in turn require support to adapt to these changes (IFAD 2013, Fedele *et al*. 2019). According to the Food and Agriculture Organization of the United Nations (FAO), the negative impacts of climate change will be most severely felt in the Least Developed Countries (FAO 2017). Several studies have shown that Africa is the most vulnerable continent (e.g. Rockstrom 2000, Sonwa 2018, Sarkodie and Strezov 2019). This vulnerability is attributed to limited skills and equipment for disaster management, inadequate financial resources (poverty), weak institutional capacity, heavy dependence on rain-fed agriculture, as well as socioeconomic and ecological conditions (Rockstrom 2000, Mulwa *et al*. 2017, Sonwa *et al.* 2017, Agovino *et al*. 2018, Sonwa 2018). Sarkodie and Strezov (2019) summarise Africa's vulnerability by reporting that Africa has a high sensitivity, high exposure, and low adaptive capacity.

Studies have asserted that climate change will continue at an accelerating rate, thereby raising the adaptation challenge for agriculture (IPCC 2013, Fan *et al.* 2017), and that this poses a major and growing threat to global food security (FAO 2018). Thus, as the impacts of climate change on agriculture intensify, it will become increasingly difficult to grow crops, raise animals, manage forests, and catch fish in the same ways and same locations as in the past (FAO 2016). This situation exacerbates the vulnerabilities of poor farmers in rural areas, whose livelihoods primarily depend on agricultural, forestry, and fishery resources, by creating major challenges to attaining sustainability through the depletion of natural resources (Agovino *et al*. 2018). Adesina and Odekunle (2011) posit that to effectively address adaptation to climate change, it is critical to have clear perceptions of the vulnerabilities of ecological, economic, and social systems within a country. Hence, there is an urgent need to continue seeking reliable solutions to the numerous problems posed by pervasive climate change. This further heightens the need for assessing vulnerability.

Vulnerability has been defined as the degree to which a system is susceptible to, or unable to cope with, the adverse effects of climate change, including climate variability and extremes (IPCC 2007). This definition embodies three elements often used to assess vulnerability: the exposure of a system to climate variations, its sensitivity, and its adaptive capacity (Luers *et al.* 2003, Turner *et al.* 2003, Füssel and Klein 2006, IPCC 2007). Exposure refers to the degree of climate stress to which a particular unit or system is exposed. The stress could be changes in climate conditions or variability in climatic behaviour, including the magnitude and frequency of extreme events (O'Brien *et al*. 2004). Sensitivity is the degree to which a system is modified or affected by an internal or external disturbance or set of disturbances (Adesina and Odekunle 2011). Several approaches to climate change adaptation exist and one of them is the management of agrobiodiversity.

Agrobiodiversity has been identified as a key indicator of the sustainability of food systems (Sthapit *et al*. 2017). In addition, agro-ecological practices promoting the optimal use of crop genetic diversity (Hajjar *et al*. 2008) can sustainably intensify agricultural production, whilst simultaneously increasing ecosystem resilience and reducing gas emissions per unit of production (Hughes *et al*. 2008), and contributing immensely to the global resilience of agriculture-based communities.

Several studies have been undertaken to address adaptation to climate change in Cameroon. For example, Ngondjeb (2013) assessed the impact of climate change and adaptation options of agriculture in the Sudano-Sahelian zone of Cameroon. Tingem *et al*. (2008) studied the impact of climate change on crop production, whilst Brown and Sonwa (2015) investigated rural local institutions and climate change adaptation in Cameroon's forest communities. These studies did not tackle the issue of climate change vulnerability, with the exception of Fongnzossie *et al*. (2018). Their study assessed vulnerability of coastal dwellers to climate risks in the Campo-Kribi area of Cameroon. Hence, assessing vulnerability with the aim of providing more information for climate change adaptation planning is an ongoing research target for Cameroon. The objectives of the present study were to assess the vulnerability of farmers in Southern Cameroon and examine the potential for adaptation of agrobiodiversity in natural farmers' livelihood support systems, with a special focus on the Ayos and Bokito communities. The study sought to describe the vulnerabilities of these communities and the factors that explain them to understand the agrobiodiversity stock of each site and determine how it can contribute to climate change adaptation.

2. Material and methods

2.1. Study sites

The study was conducted in Ayos in the Nyong and Mfoumou Division of the Centre Region of Cameroon, and in Bokito in the Mbam and Inoubou Division of the Centre Region of Cameroon (Figure 1). Ayos is located east of the capital Yaounde, whilst Bokito is found west of Yaounde. Yaounde is the main urban market for both areas. The climate of Ayos is humid tropical whilst that of Bokito is humid subtropical. However, both areas are characterised by the same seasons:

- A long dry season from mid-November to mid-March, characterised by end of year festivities in the early part of the season and farm preparation activities for replanting towards the end of the season;
- A short rainy season from mid-March to mid-June during which farmers concentrate on crop cultivation and most especially short-cycle crops;
- A short dry season from mid-June to mid-August during which farmers harvest some of the crops planted during the short rainy season and also prepare farm plots to receive seeds during the long rainy season; and
- A long rainy season from September to mid-November with major farming activities.

The vegetation of Bokito is dominated by herbaceous and shrubby savannah grassland whilst Ayos is dominated by gallery forests and Raphia swamp forests. Bokito has a population of 72,000 inhabitants, spread across 36 villages, with a total surface area of 1,115 km². Ayos has a population of 22,899 inhabitants with 29 villages and a total surface area of 1,250 km².

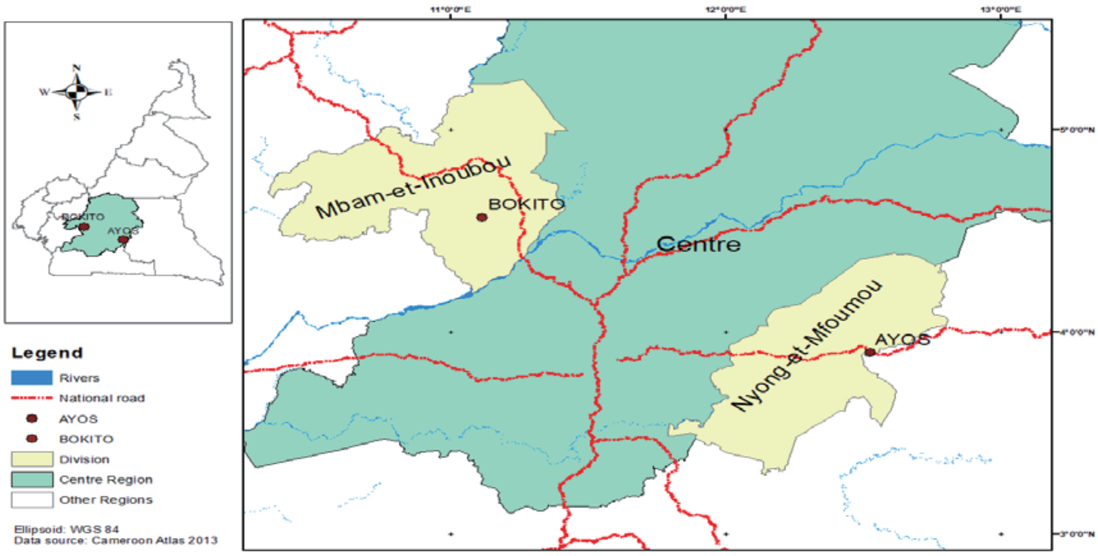

Figure 1. Map indicating study sites

2.2. Vulnerability assessment framework

Vulnerability arises from complex interactions between socio-economic, institutional and environmental systems, which complicate any assessment or quantification (Krishnamurthy 2014). Hence, several approaches have been developed to assess vulnerability to climate change in different contexts. However, there is no 'one size fits all' method for the assessment of vulnerability. Doch *et al.* (2015) reported that vulnerability assessments link the social and biophysical dimensions of environmental change. Several authors conceptualise vulnerability as the exposure of a system to hazards, sensitivity of the system to change, and its adaptive capacity to the changes in the environment (IPCC 2007, 2013, Heng *et al*. 2013). The vulnerability assessment framework developed by the Intergovernmental Panel for Climate Change (IPCC 2007) has been widely used to analyse vulnerability, due to its robustness and adaptability. This approach uses indicators to assess vulnerability through a vulnerability index.

2.3. Data collection procedure

Data were collected through focus group discussions and completed using the council development plans of the two areas. The focus group data were collected in 31 villages and these were selected based on the size of their population, access to the market, and ethnicity (Table 1).

Table 1. Villages where focus group data were collected

Ayos		Bokito	
Village	Number of participants	Village	Number of participants
Nsan 1	10	Tchekos	8
Niamvoudou	10	Omeng	8
Wong	10	Tobagne	11
Ebeck	18	Bongo	7
Ndelle	14	Batanga	19
Abeng Nnam	25	Yangben	13
Melan	10	Kedia	9
Yebe	8	Bokaga	24
Ngoun 2	23	Guefigue	17
Mbaka	13	Yambassa	16
Tomba 1	7	Bogando	10
Akam Engali	20	Balamba	11
Mbang	13	Yoro	32
Olembe	7	Assala 1	16
Nyabewa	7	Begni	9
Biwo	7		
Total	202	Total	210
Grand total	412		

2.4. Data analysis

The data were analysed using the SPSS software. The weighting of indicators was done through ranking scores provided during focus group surveys, and expert judgments. The indicators for sensitivity, exposure and adaptive capacity were chosen through literature review of multiple vulnerability studies (e.g. Adesina and Odekunle 2011, Atedhor 2015, and Žurovec *et al*. 2017) and focus group data. The weighted values were further used to compute Vulnerability (V) using the equation developed by Gehendra (2012):

$$\mathbf{V = (E \times S)/AC}$$

Where V: vulnerability, E: exposure, and AC: adaptive capacity.

The vulnerability of each community was categorised using five ranking classes, as used by Fongnzossie *et al*. (2018), as follows:

Low: $V \leq 1$; Medium: $1 < V \leq 2$; High: $2 < V < 4$; Very high: $V \geq 4$. Where, V= Vulnerability Index.

Descriptive statistics were used to summarise the adaptation strategies of farmer communities.

3. Results

3.1. Exposure

3.1.1. Farmers' perceptions on temperature, rainfall, and other biophysical climate variables

All farmers in Ayos and Bokito acknowledged that the seasons are changing. A high number of villages (26 villages) in both sites also reported less rainfall, the shortening of the rainy season and longer duration of droughts and frequent whirlwinds. Higher temperatures were reported more frequently in Bokito.

3.1.2. Farmers perception of climate change impact

Farmers in Ayos and Bokito both reported the prevalence of plant pest and diseases, and land degradation as the biggest impacts of climate change (Table 3). Farmers in Bokito reported the drying of soils frequently as the most severe impact of droughts on their livelihood support systems, which includes water sources and difficulty in undertaking tillage farming practices. Farmers in Ayos villages indicated that crop failure was more severe.

Table 2. Farmers' perception of climate variables

Climatic variable	Number of villages signalling event	
	Ayos	Bokito
Less rainfall	15	11
Number of rains vary	1	3
Number of rains increase	0	1
Early onset of rains	2	5
Late onset of rains	1	1
Unpredictable onset of rains	13	9
Shortening of rainy season	14	13
Lengthening of rainy season	0	1
Early ending of rains	9	8
Unpredictable ending of rains	6	6
Frequent occurrence of droughts	12	2
Varying occurrence of droughts	12	12
Long duration of droughts	10	14
Higher temperatures	3	8
Extreme hot and cold temperatures	3	6
Varying temperatures	7	15
More frequent and violent winds with storms	15	12

Table 3. Impacts of climate change per number of villages listing them per site

Impact	Number if villages signalling impact	
	Ayos	Bokito
Poor growth of plants	2	9
Crop failure	4	1
Destruction of crops	6	4
Drying of soils	3	8
Destruction of houses	2	2
Drying of crops	2	7
Rivers drying up	8	15
Land degradation	8	9
Prevalence of crop pests and diseases	14	12
Human health problems	5	11

3.1.3. Occurrence of extreme climatic events

Major, extreme climatic events recorded in the study area were violent winds and long droughts. The drought conditions could be responsible for the water scarcity and recurrent drying of rivers in Bokito.

3.2. Sensitivity

3.2.1. Relative livelihood importance of forest, savannahs, and other land use types

Five major functional landscapes were identified on the study site based on community perception (streams and rivers, savannah, forest, fallows and croplands) but for functionality reasons, fallows and cropland were merged and referred to as farmland (farming systems) . The results revealed that the most important landscape for the provision of trade products was farmland for both sites, followed by forest and aquatic areas (streams and rivers) in Ayos only. The forest emerged as the most important landscape for construction materials, followed by rivers/streams and farmland with a higher relative importance for farmland in Ayos. The major hunting ground for the Ayos community was forest whilst the major hunting grounds for Bokito were savannahs and forests. Fishing activities were more important in Ayos than in Bokito.

On a general note, the Ayos community recorded a higher dependence on resources favoured by the presence of a forest than the Bokito community, who showed a higher dependence on agriculture (Table 4), although agriculture was practiced in both forest and savannah landscapes. This confirms the place of savannahs in the society, as highlighted by Boke-Olén *et al*. (2016) who reported that savannahs are particularly important because they are populated with societies dependent on subsistence farming.

Table 4. Relative importance of landscapes for the provision of goods and services

Goods and services	Streams/rivers		Savannah		Forest and forest products		Farmland	
	Ayos	Bokito	Ayos	Bokito	Ayos	Bokito	Ayos	Bokito
Trade products	20.80	9.35	2.14	6.33	35.27	15.62	41.79	68.70
Construction	19.50	17.90	1.04	2.86	61.38	70.35	18.08	8.89
Food	20.78	14.43	0.78	13.97	36.72	16.09	41.72	55.50
Fuelwood	1.79	1.90	2.29	24.75	61.74	41.86	34.18	31.49
Hunting	7.00	5.62	4.43	51.86	63.67	40.24	24.9	2.28
Tools	1.94	2.22	2.50	20.06	69.4	2.11	26.16	15.61
Traditional medicine	11.88	10.12	2.08	21.12	63.85	52.64	22.19	16.12
Total	83.69	61.54	15.26	140.95	392.03	298.91	209.02	198.59

3.3. Adaptive capacity

3.3.1. Literacy rate

Within the framework of this study, the literacy rate was considered as the proportion of the persons in a community that could read and write. The average literacy rate was 60.91 % for Ayos and 79.73 % for the community of Bokito. In Ayos, the highest literacy rate was 98 %, whilst the lowest was 45 %. For Bokito, the highest literacy rate was also 98 %, whilst the lowest was 50 %.

3.3.2. Sanitation

Sanitary infrastructure was absent in most villages. In villages where this was present, the quality of service rendered to the populations was generally poor due to the lack of equipment and an insufficiency of qualified staff.

3.3.3. Housing quality

Houses in the two study sites were generally made of thatch, mud, planks, and cement bricks. The majority of houses in most villages were poorly constructed thatched houses. Housing quality was better in Bokito than in Ayos.

3.3.4. Markets and transportation

In Ayos, the main market is located in the Ayos urban area. Braving the odds of bad roads, which are mostly unmaintained earth roads (in 14 villages), is a major constraint for farmers to market their products and/or to obtain substitutes for household consumption. Villages located a great distance from the divisional headquarters suffer more, as the majority of goods transportation is conducted by motor bikes, which carry very small quantities. There are periodic markets (once a week) in some villages in the vicinity of Bokito that give some farmers the opportunity to sell their products without having to transport them. Roads in the Bokito area are also predominantly earth roads with very high levels of inaccessibility. Motor bikes are also the main transportation means, but private vehicles intervene occasionally in the transportation of goods.

3.3.5. Organisations

The study found that at the village level there were very few local institutions and associations working in the domain of agriculture and conservation. Focus group results also revealed a low level of collaboration among farmers, hence making it difficult for them to create and manage their cooperatives and farmer groups.

3.4. Vulnerability

The analysis of data revealed a high number of farmers being moderately vulnerable with a very high vulnerability obtained for only one village in the Bokito community (Table 5).

Table 5. Exposure, sensitivity, adaptive capacity and vulnerability index per village

Site	Village	Exposure index	Sensitivity index	Adaptive capacity index	Vulnerability index
Ayos	Nsan 1	1.67	2.13	1.57	2.25
	Niamvoudou	1.67	1.63	1.43	1.90
	Wong	1.67	2.00	1.14	2.92
	Ebeck	1.67	2.00	1.43	2.33
	Ndelle	1.67	1.88	1.71	1.82
	Abeng Nnam	1.67	1.88	1.43	2.19
	Melan	1.67	2.13	1.14	3.10
	Yebe	1.67	2.13	1.29	2.75
	Ngoun 2	1.67	2.00	1.14	2.92
	Mbaka	2.22	1.88	1.57	2.65
	Tomba 1	1.78	2.00	1.57	2.26
	Akam Engali	1.78	2.00	1.14	3.11
	Mbang	1.89	1.88	2.00	1.77
	Olembe	1.78	1.75	2.00	1.56
	Nyabewa	1.78	2.00	1.57	2.26
	Biwo	1.78	2.00	1.29	2.77
Bokito	Tchekos	2.11	2.00	1.29	3.28
	Omeng	2.44	2.00	1.14	4.28
	Tobagne	2.56	2.00	1.43	3.58
	Bongo	2.56	2.00	1.43	3.58
	Batanga	2.56	1.88	1.43	3.35
	Yangben	2.56	2.00	1.57	3.25
	Kedia	2.56	2.00	1.71	2.98
	Bokaga	2.56	2.00	2.00	2.56

	Guefigue	2.56	2.00	1.86	2.75
	Yambassa	2.56	1.88	2.00	2.40
	Bogando	2.56	2.00	1.57	3.25
	Balamba	2.56	2.00	1.43	3.58
	Yoro	2.56	2.00	1.43	3.58
	Assala 1	2.56	1.88	1.86	2.58
	Begni	2.56	1.88	1.57	3.05

3.5. Local adaptation strategies

Farmers use different local strategies to cope with the effects of climate change, mainly based on the impact. In Ayos, farmers mostly resorted to fallowing, the use of fertilisers, cultivation in swampy areas, waiting for rains, mixed cropping, replanting, and crop replacement, as climate adaptation strategies (Table 6). However, some farmers lack adaptation strategies and bear the consequences of climate change. In Bokito, the major local adaptation strategies were fallowing, planting of cocoa in savannah, mixed cropping, crop replacement, and planting of trees. Farmers revealed that in the past, cocoa was cultivated only in the small forest patches of Bokito.

Table 6. Local adaptation strategies reported by farmers

Adaptation strategy	Number of villages that listed them	
	Ayos	Bokito
No adaptation strategies	2	2
Wait for rains before planting	4	2
Replanting	3	5
Mixed cropping	5	7
Anticipation of planting	4	1
Crop replacement	2	4
Planting of trees	3	3
Planting cocoa in savannah	3	5
Farming in swampy areas	4	1
Use of pesticides and insecticides	1	1
Fallowing	6	10
Use of fertilisers	5	1

3.6. Agrobiodiversity in forest landscape of Southern Cameroon

3.6.1. Agrobiodiversity in cultivated species

The study revealed that similar food crops are cultivated in the two study areas. However, the main food crops cultivated in Ayos are cassava, plantain, groundnuts, and egusi. These crops are often mixed with other crops, including maize and cocoyams. In Bokito the major cultivated food crops are maize, cocoyams, plantain, groundnuts, yams, egusi, and sweet potatoes. The planting of fruit trees is practiced more frequently in Bokito than in Ayos. The major cash crop cultivated in Bokito is cocoa, with a large number of plantations established in savannah areas, whereas two major cash crops are cultivated in Ayos (coffee and cocoa). Market gardening is more developed in Bokito with a high level of cultivation of tomatoes and pepper.

Table 7. List of agrobiodiversity in cultivated plant species

Scientific name	Family	Common/local name	Ayos	Bokito
Alium cepa	Liliaceae	Local onion	×	
Amaranthus esculentus	Amaranthaceae	Amaranth	×	×
Amaranthus hibridus	Amaranthaceae	Amaranth	×	×
Annona muricata	Annonaceae	Soursop	×	×
Arachis hypogaea	Fabaceae	Groundnut	×	×
Capsicum annuum	Solanaceae	Poivron	×	×
Capsicum fructescens	Solanaceae	Pepper	×	×
Carica papaya	Caricaceae	Paw paw	×	×
Citrullus lanatus	Cucurbitaceae	Watermelon	×	×
Citrus aurantium	Rutaceae	Lime	×	×
Citrus limon	Rutaceae	Lemon	×	×
Citrus paradisi	Rutaceae	Pamplemouse	×	×
Citrus reticulata	Rutaceae	Mandarin	×	×
Citrus sinensis	Rutaceae	Orange	×	×
Cocus nucifera	Arecaceae	Coconut		×
Coffee spp.	Rubiaceae	Coffee	×	×
Colocasia esculenta	Araceae	Taro	×	×
Cucumeropsis mannii	Cucurbitaceae	Egusi	×	×
Cucurbita pepo	Cucurbitaceae	Pumpkin	×	×
Dacryodes edulis	Burseraceae	Safou	×	×
Dioscorea spp.	Dioscoreaceae	Yams	×	×
Elaies guineesis	Arecaceae	Oil palm	×	×
Glycine max	Fabaceae	Soybean		
Ipomoea batatas	Convolvulaceae	Sweet potatoes	×	×
Lactuca sativa	Asteraceae	Lettuce		×
Legenaria siceraria	Cucurbitaceae	Calabash		×
Mangifera indica	Anacardiaceae	Mango	×	×
Manihot esculenta	Euphorbiaceae	Cassava	×	×
Musa paradisiaca	Musaceae	Plantain	×	×
Musa sapientum	Musaceae	Banana	×	×
Ocimum gratissimum	Lamiaceae	Messep		×
Persea americana	Lauraceae	Avocado	×	×

Phaseolus vulgaris	Fabaceae	Beans	×	×
Psidium guayava	Myrtaceae	Guava	×	×
Saccharum officinarum	Poaceae	Sugarcane	×	×
Sesamun indicum	Pedaliaceae	Sesame		×
Solanu tuberosum	Solanaceae	Irish potatoes	×	×
Solanum lycopersicum	Solanaceae	Tomatoes	×	×
Solanum macrocarpon	Solanaceae	Eggplant	×	×
Solanum nigrum	Solanaceae	Black nightshade	×	×
Spondias cytherea	Anacardiaceae	Casmanga	×	×
Talinum triangulare	Portulacaceae	Waterleaf		×
Telfairia occidentalis	Cucurbitaceae	Fluted pumpkin	×	
Theobroma cacao	Malvaceae	Cacao		×
Vernonia amygdalina	Asteraceae	Bitterleaf	×	×
Xanthosoma sagittifolium	Araceae	Macabo	×	×
Zea mays	Poaceae	Maize	×	×
Zingiber officinale	Zingiberaceae	Ginger		×

3.6.2. Agrobiodiversity in wild plant species

The study revealed a higher number of wild plants used for food and nutrition in Ayos. Among these species, many are not found in Bokito. Examples include *Garcinia cola*, *Cola ricinofolia*, and *Baillonella toxisperma* (Table 8). Additionally, T*etracarpidium conophorum*, which is found in Bokito, does not occur in Ayos.

Table 8. List of plant agrobiodiversity in wild plant species

Scientific name	Family	Common/local name	Ayos	Bokito
Acalypha ornata	Euphorbiaceae	Sondo	×	
Aningera robusta	Sapotaceae	Abam	×	
Annona muricata	Annonaceae	Wild soursop	×	×
Baillonnella toxisperma	Sapotaceae	Moabi	×	
Beilschmidia obscura	Lauraceae	Kanda	×	
Bulchozia cariacea	Piperaceae	Lion's cola	×	
Canarium schweinfurthii	Burseraceae	Canarium	×	×
Cola acuminata	Malvaceae	Cola nuts	×	×
Cola ricinifolia	Malvaceae	Monkey's cola	×	
Coula edulis	Olacaceae	Komen	×	
Dacryodes macrophylla	Burseraceae	Tom	×	×
Garcinia cola	Clusiaceae	Bitter cola	×	
Gnetum spp.	Gnetaceae	Eru	×	
Irvingia gabonensis	Irvingiaceae	Bushmango	×	×
Monodora myristica	Myristicaceae	Pebe	×	
Myrianthus arboreus	Cercropiaceae	Mva'a	×	
Nuclea diderichii	Rubiaceae	Angokom	×	
Nuclea pobeguinii	Rubiaceae	Akondoc	×	
Ocimum sp.	Lamiaceae	Masseb	×	
Pentaclethra macrophylla	Leguminosea	African bean tree	×	

Piper guineense	Piperaceae	Bush pepper	×	×
Ricinodendron heudelotii	Phyllanthaceae	Njansang	×	×
Tetracarpidium conophorum	Euphorbiaceae	African walnut		×
Tricoscypha acuminata	Anacardiaceae	Mvut	×	
Uapaca spp.	Cannabaceae	Ezen	×	
Voacanga africana	Apocynaceae	Voacanga	×	
Xylopia staudtii	Annonaceae	Avom	×	
		Caterpillars	×	
		Mushroom	×	×

3.6.3. Agrobiodiversity of domestic animals (livestock)

Similar domestic animals were being reared in the two study areas. However, the varieties of these animals were mainly local. In addition, animal rearing was practiced on a small scale in both communities.

Table 9. Diversity of livestock in Southern Cameroon.

Scientific name	Family	Common/local name
Bos taurus	Bovidae	Cattle
Canis lupus familiaris	Canidae	Dog
Capra hircus	Bovidae	Goat
Carina mischata	Anatidae	Domestic duck
Felis catus	Domestic cat	Domestic cat
Gallus gallus domesticus	Phasianidae	Domestic fowl
Ovis aries	Bovidae	Sheep
Sus scrofa domesticus	Suidae	Pig

3.6.4. Agrobiodiversity in wild animals (wildlife) and fishery resources

The study revealed a rich diversity of wild animals are used as food (Table 10). However, variations in availability of the animals exist, with bush meat being increasingly available in the Ayos forest area. Bokito farmers reported low availability, mainly due to the bushfires and overgrazing on the savannah landscape, which chase away animals. Bushfires also cause habitat destruction thereby reducing animal availability and causing land degradation.

Table 10. Agrobiodiversity in wildlife

Scientific name	Family	Common/local name
Atelerix sp.	Erinaceidae	Hedgehog
Cephalohus dorsalis	Bovidae	Bay duiker
Cephalophus callipygus	Bovidae	Peter's duiker
Cercopithecus erythrotise	Cercopithecidae	Red eared monkey
Crossaculius	Viverridae	Mangoust

Dendrolyrax arboreus	Procaviidae	Dama/Tree hendrax
Epus europaeus	Erethizontidae	Porcupine
Gazella sp.	Bovidae	Gazelle
Lepus europaeus	Leporidae	Rabbit
Manis spp.	Manidae	Pangolin
Pelusios gabonensis	Testudinidae	Bells hinged tortoise
Potamochoerus larvatus	Suidae	Bush pig
Sciurus sp.	Sciuridae	Squirrel
Thryonomys	Thryonomyidae	Greater cane rat
Tragelaphus sp.	Thryonomyidae	Cane rat
Vivera civetta	Viverridae	Civet

Major rivers in both areas are rich in fishery resources that support human life. However, these resources are more abundant in Ayos than Bokito. In addition, *Hererotis niloticus* (Kanga) is specific to the Ayos site in the Nyong River. Farmers in Ayos also practice fishing throughout the year, with the exception of the period of very heavy rains when rivers are flooded and high risk.

Table 11. Fishery resources that are used as food in Southern Cameroon

Scientific name	Family	Common name
Oreochromis niloticus	Cichlidae	Tilapia
Hererotis niloticus	Osteoglossidae	Kanga
Brachyura sp.	Ocypodidae	Crabs
Channa sp.	Channidae	Snakefish
Ciprinus carpio	Cyprinidae	Carp
Esox lucius	Esocidae	Brochet
Holothuria sp.	Holothuriidae	Pentard
Neochanna burrowsius	Galaxidae	Mud fish
Penaeus monodon	Astacidae	Crayfish
Silurus sp.	Siluridae	Catfish
		Aquatic snails
		Oysters

Reptiles used as food in the study area include *Nana* spp. (Elapidae), *Varanus* spp. (Varanidae), *Bitis gabonica* (Viperidae), *Dendroaspis angusticeps* (Elapidae), and *Gongylophis* sp. (Boidae).

4. Discussion

4.1. Vulnerability to climate change and agrobiodiversity potential of Southern Cameroon

In the last decade, farmers have recognised the impacts of climate change in the study area. Farmers reported lower amounts of rainfall, the shortening of the rainy season, longer duration of droughts, and frequent whirlwinds. Several studies have reported similar variability of climate factors (e.g. Fongnzossie *et al*. 2018). These changes caused numerous impacts, including prevalence of crop pests and diseases, land degradation, and human health problems. Additional studies (e.g. Travis *et al*. 2015) obtained similar results.

The results demonstrated that farmers in both localities (Ayos and Bokito) were vulnerable to climate change. However, one village in Bokito (Omeng) had high vulnerability. The high vulnerability index value of this village reflects the reality observed in the field, and can be explained by its poor access, low literacy rate, poor health and education facilities, and limited access to the market. The road linking this village to the subdivisional headquarters of Bokito is an unmaintained earth road crossed by a big river lacking a bridge. Farmers here face tough circumstances in order to transport their goods to the nearest market. This area was also highly dependent on rain-fed agriculture, thereby increasing its vulnerability. Similar results were obtained by Oo *et al*. (2018). On a general note, more villages in the Bokito area recorded moderate vulnerability indices than in the Ayos area. This result aligns with the high level of sensitivity of the different landscapes to climate change. In addition, Ayos communities were less dependent on agriculture when compared to Bokito. Several studies have shown that farming communities that are highly dependent on agriculture are more likely to be vulnerable to the impacts of climate change. The vulnerabilities of these villages can also be associated with their socioeconomic characteristics, extreme climatic events (long droughts, high temperatures, and erratic rains) and their ecological profile (Mekonnen *et al*. 2019).

Despite several developed strategies, adaptation to climate change appears to be difficult for farmers. This suggests that the vulnerability of farmers may be determined by the availability of public infrastructure such as roads, bridges, markets, and health and educational facilities. Furthermore, extension services and conservation institutions were lacking in both localities, thereby preventing farmers from acquiring knowledge that could facilitate their adaptation.

The study revealed that farmers in the two areas cultivated similar food crops. However, differences could be observed in the main crops that were cultivated. Farmers in Ayos cultivated mostly cassava, groundnut, plantain, and cocoyam. These are the staple food crops they use in their meals with bush meat and freshwater fish. This feeding habit is part of their culture and might contribute to the vulnerability of the farmers. Thomas *et al*. (2018) argued that culture could be used to clarify the adaptive capacity of local communities, as it could be the basis for decisions taken by farmers. Meanwhile, farmers in Bokito cultivated more maize, cocoyams, plantain, groundnuts, yams, egusi and sweet potatoes. However, farmers in Bokito adopt new crops more frequently than farmers in Ayos.

Major differences were observed between Ayos and Bokito in terms of agrobiodiversity in wild plant species. These differences arise from the variation in landscapes. Ayos has higher forest cover than Bokito, which is endowed with few patches of forest and more savannahs. The greater number of wild plant species available for food reduces the vulnerability of farmers. This result is supported by the findings of Fongnzossie *et al*. (2018) who observed that farmers resort to the collection of non-timber forest products as strategies to adapt to the impacts of climate change. Since there are limited forestlands in the Bokito area, there appears to be greater pressure facing these resources from local populations. This may account for the diminishing forest resources in the area. This might also explain why farmers in recent years, have relied on the cultivation of cocoa in savannahs alongside an increased intensity in the cultivation of subsistence food crops in swampy areas.

4.2. Linking climate change adaptation and agrobiodiversity in Southern Cameroon

Farmers in Southern Cameroon are exposed to the risks of climate change. Managing agrobiodiversity sustainably in the area appears to be a better option for adaption. However, this management is dependent on the legitimate power that governs the collection of natural agrobiodiversity and power related issues around the landscape include land disputes. In these situations, the groups who are most vulnerable are the poor, widows, orphans, and youths. The youth have limited access to land due to such disputes and are therefore more exposed to climate risks. According to The World Bank (2005), because natural resources are such an important source of value for so many people, it is of little surprise that politics and power relations should strike at the heart of natural resource management. Power could influence access to land in a biased manner.

A strong correlation in many societies has been identified between the decision-making powers that a person enjoys, and the quantity and quality of land rights held by that person (FAO 2002). Access to land is often regulated by the land tenure system. In most rural areas, including the study area, only the male children have access to land inheritance. This increases vulnerability of unmarried women and widows in rural areas. This affirmation is supported by the studies of Brown (2011), who showed that women are dependent on agricultural and forest resources for their livelihood and are often marginalised within the society. Orphans, whose parents die young, suffer from the seizure of their land by their paternal uncles, as well as influential people and elites in the community. Fairbairn (2013) argued that elites exercise 'access control' over land may contribute to community dispossession despite a national legal framework that protects peasant land rights. Such influences limit the availability of agricultural land for poor rural farmers.

5. Conclusion

This study revealed that farmers perceived climate variability in Southern Cameroon. The savannah ecotone of Southern Cameroon is increasingly sensitive and exposed to climate change than the forest zone. Farmers in both areas also use different measures to cope with climate change. The majority of villages in the two communities are moderately vulnerable to climate change. A large potential of agrobiodiversity was obtained for Southern Cameroon, with a higher diversity in the Ayos site. From this, we can conclude that the Ayos community has more safety nets, through the agrobiodiversity present in its livelihood support systems, than the Bokito community, which is more agriculture-dependent.

The vulnerability trends of farmers can be reversed through the sustainable management of the rich agrobiodiversity of the study area. It is therefore imperative for policy makers, adaptation planners and private initiatives working in Southern Cameroon to place agrobiodiversity management at the centre of action in all the life-support systems, including agrobiodiversity. Additionally, agrobiodiversity needs to be incorporated in climate-smart agriculture in Southern Cameroon. Alongside this, good institutional frameworks are required at the local level, through which national and regional policies can address the impacts of climate change and provide more options for climate adaptation.

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